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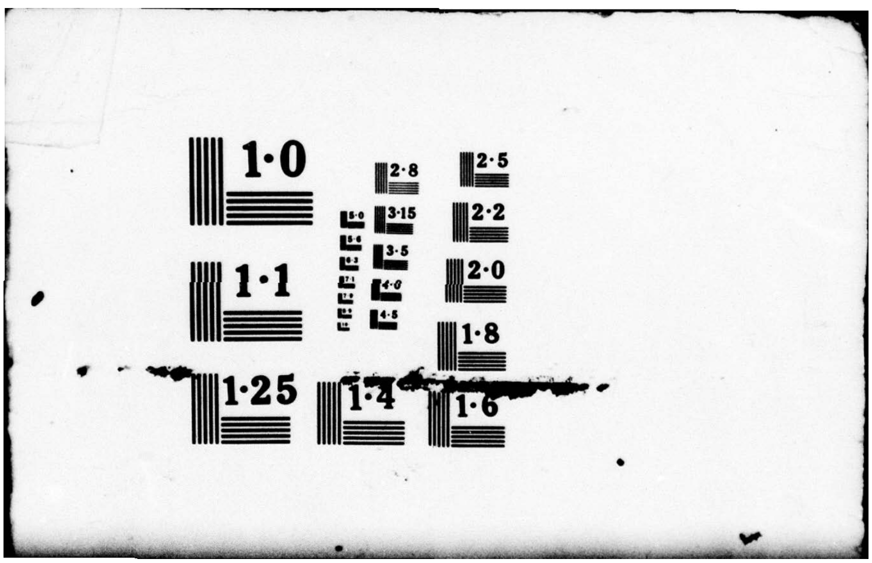
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RESEARCH AND DEVELOPMENT TECHNICAL REPORT

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ARMY STANDARD ELECTRONIC MODULES (SEM) REQUIREMENTS

Charles P. Lascaro

ELECTRONICS TECHNOLOGY & DEVICES LABORATORY

November 1978

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A study was conducted to determine US Army Standard Electronic Module requirements in order to ascertain the potential for reducing proliferation of subassembly electronics, research and development lead time, life cycle costs and logistic burdens. The following four equipment platform types were studied: manpack, avionics, ground support (test) and mobile-vehicle. Data indicated that usage of printed wiring assemblies occurred at certain peak sizes. All of the equipment environmental requirements were reduced to one class. The Army → over

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peak sizes were compared with Navy Standard Electronic Modules and Air Force SAMP-ATR modules. Selected module design criteria were prioritized to apply to each equipment platform type studied.

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ARMY STANDARD ELECTRONIC MODULES (SEM) REQUIREMENTS

INTRODUCTION

This study was initiated by the US Army Electronics Research and Development Command (ERADCOM) as a result of a request from the US Army Materiel Development and Readiness Command[1] to evaluate Standard Electronic Module programs of the Air Force and Navy and to provide information on the Army's plans for Standard Electronic Module (SEM) usage. Coordination with the Avionics Systems Command, the Missile Command and the Armaments Command resulted in ERADCOM being designated as the "lead" laboratory in the study.

A subpanel on standard modules was established on 7 February 1975 under the Electronics Panel of the Defense Materiel Specifications and Standards Board (DMSSB), Office of the Assistant Secretary of Defense (OASD). This panel was created in order to examine the merits, means and long-range implications of the more wide-spread use of standardized micro-electronic functional modules. The DMSSB study, in which this command participated, provided an opportunity to survey Navy and Air Force SEM programs; the results of which were used for background information in the Army study. The results of the DMSSB SEM Subpanel study were included in their final report[2] and some of these results are included in this report.

Two previous paper-design studies conducted for the Army by Hydrospace Challenger Inc., on the conversion of the TD-1069 Time Division Multiplexer and the UYK-15 Computer[3] to Navy SEM, provided data which indicated promise of achieving many of the Army objectives. While improvements were indicated in reliability and life cycle costs, the Navy SEM had disadvantages in weight, volume and pin counts for a number of Army applications.

OBJECTIVES

The following are the broad objectives usually associated with military SEM study programs:

- Reduction of electronic module proliferation.

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1 "Standard Electronic Modules", CDR, DARCOM Message 181931, 4 Jul 1974.

2 Wyatt, J.A., Porter, L.E., Lascaro, C.P., Reich, B., et al.; Final Report,"Standard Modules Subpanel to the Electronics Panel", Defense Materiel Specifications and Standards Board, Aug 1976.

3 "Analysis of the Time Division Multiplexer TD-1069(XE1)/G and Univac AN/UYK-15 Digital Computer Implemented with SEMP Modules", Dec 1976. EGG, Hydrospace Challenger, Army MIPR to Contract N000-39-75-C-0075.

- Maximum use of SEM in Army equipment.

- Higher module reliability, longer shelf life and lower life cycle costs.

- Reduction of Army logistic and maintenance burdens.

- Acceptance of advanced designs and circuit technology.

- Complement form-fit-function (F^3) equipment programs.

- Reduction of research and development lead times.

- Easier processing with computer aided or design automation module designs.

- Facilitation of module specification, qualification approval and interchangeability.

While the above general objectives serve to fit longer range program studies, it was determined that the specific objectives for this introductory Army SEM study would be limited to determining potential SEM needs and promising areas for their usage.

For the limited purposes of this study, Army equipments were selected for study which were likely candidates to use or adapt to SEM designs. The Army equipment platform types selected included manpack, avionics, ground support (test) and mobile-vehicle equipments. For each platform type and selected system types, mechanical-environmental data of printed wiring design were collected, collated and analyzed.

DATA ACQUISITION

Army electronic equipments selected for this study were classified into four platform categories and six electronic system function types.

PLATFORM CATEGORIES	SYSTEM FUNCTIONAL TYPES
Manpack	Radar
Avionics	Digital Data Processing
Mobile-Vehicle	Communication
Ground Support (test)	Command Control Centers
	Test Equipments
	Navigation

To assure coverage of each of the above platform categories and function types, and to also minimize data acquisition, the selection of equipments to be studied were grouped in a matrix (See Table 1). For each equipment studied, the following data were obtained:

TABLE 1, ARMY SEM STUDY MATRIX

EQUIPMENT PLATFORM CATEGORIES ↓ / ELECTRONIC SYSTEM TYPES →	RADAR	DIGITAL DATA PROCESSING	COMMUNI-CATIONS	COMMAND CONTROL CENTERS	TEST EQUIPMENT	NAVIGATION
MANPACK			PRC-70 PRC-77 VRC-78			
MOBILE VEHICLE	TPQ-36 TPQ-37	TTC-38 TTC-39		TSQ-73 SAM-D GSG-10 (TACFIRE)		
AVIONICS			ARC-115 ARC-164			ARN-89
GROUND SUPPORT					USM-410 APM-305 TPM-25 APM-123	

Platform Data:

Equipment Environmental Requirements

Module Sizes:

width

height

thickness, pitch

circuit area

population

Connector:

pin spacing

pin socket type

This report reduces and summarizes the above data which are used as justification in the support of mechanical (form-fit) and environmental requirements for Army SEMs.

DATA REDUCTION

a. Composite Equipment Environmental Class: Table 2 lists the equipment environmental requirements grouped for each equipment platform category listed in the matrix. Rain, immersion and dust environments were considered relevant only to equipment case design factors and not related to modules and therefore, were not included. In order to evolve a single composite class of equipment environmental requirements which could then be related to module environmental requirements via calculated translation factors, the maximum (worst case) environment limit was usually selected from the four platform categories, provided this would not impose unreasonable and costly design burdens on the module. Each composite equipment environment was determined as follows:

Operating Temperature: The maximum operating temperature places a burden on the module design and its enclosure to assure no more than a maximum hot-spot junction semiconductor temperature of 125^{o}C. A calculated 40^{o}C change across the module to internal equipment ambient interface lowers this temperature to 85^{o}C. A further change of 15^{o}C across the internal-to-external ambient interface resulted in an external ambient temperature of 70^{o}C which is listed as the composite maximum operating temperature in Table 2. A 70^{o}C maximum operating temperature involves no design burden on lower maximum operating temperature platforms because the same semiconductors would be used anyway. The lower -55^{o}C operating temperature does not present any module design problems.

Table 2. ARMY EQUIPMENT ENVIRONMENTAL REQUIREMENTS

(grouped by equipment platform types)

EQUIPMENT PLATFORM TYPES	TEMPERATURE °C OPERATING	NON-OPERA.	HUMIDITY	VIBRATION	SHOCK	ALTITUDE in km (ft) OPERA.	NON-OPERA.	SALT FOG MIL-STD	FUNGUS MIL-STD
Avionics	-55 to +70	-62 to +85	MIL-STD 810 (507)	MIL-T-5422 Curve III Fig 5 5-5000Hz	MIL-T-5422	15.2 km (50,000 ft)	-	810 (509)	810 (509)
MANPACK	-45 to +60	-62 to +71	SAME	MIL-STD 810, Method 514 Cat F, Proc VIII	MIL-STD 810 (516) Proc I & II	3.04 km (10,000 ft)	15.2 km (50,000 ft)	SAME	SAME
MOBILE VEHICLE	-40 to +55	SAME	SAME	SAME	SAME	SAME	SAME	SAME	SAME
GROUND SUPPORT (TEST EQUIPMENT)	-40 to +55	-62 to +85	SAME	SAME	SAME	SAME	SAME	SAME	SAME
COMPOSITE	-55 to +70	-62 to +85	MIL-STD 810 (507)	MIL-STD 810 (514), Cat C, Proc VIII, 1.6 gs	MIL-STD 810 (516) Proc I 40 gs Proc II 75 gs	9.14 km (30,000 ft)	15.2 km (50,000 ft)	810 (509)	810 (508)

Vibration: The following two vibration tests were required (See Table 2), one test for avionic equipments and one for ground equipments.

MIL-T-5422, para 4.2., Curve III, Figure 5 for Helicopters.

MIL-STD-810, Method 514, Category F, Procedure VIII, Table 514.2V, Figure 514.2.5 for Ground Equipment.

MIL-STD-810 also has a vibration test for equipment installed in helicopters, namely, Procedure I, Table 514.2-III and Figure 514.2.2, which is similar to the test specified in MIL-T-5422. A more direct comparison is shown in Table 3.

TABLE 3. VIBRATION TESTS

TEST	FREQUENCY (Hz)	PERIOD (Hrs)	AMPLITUDE mm (in)	g	SWEEP MINUTES
MIL-T-5422 (Avionic Equip)	5-500-5 sinusoidal	2-3	0.025-0.25 (0.001-01)	2-5	15-20
MIL-STD-810, Proc I Category C, (Helicopter Equip)	5-2000-5 sinusoidal	3	0.9 (0.036)	5	36
Category F, (Ground Vehicles)	5-500-5 sinusoidal	3-5	0.84 (0.03)	4.2	15

The primary difference between the helicopter test and the ground equipment test in MIL-STD-810 is the frequency curve which extends to 2000 Hz for helicopter equipment as compared to 50 to 500 Hz for ground equipment. Since the higher frequency requirements should not impose any significant design requirements on ground equipment, only one test, the MIL-STD-810, Procedure I for equipment installed in helicopters, was used for standardization purposes.

Shock: The two shock tests listed in Table 4 provide the following test conditions:

TABLE 4. SHOCK TESTS

TEST	SHOCK	g	MILLISECOND	SHOCK PULSE SHAPE
MIL-T-5422				
-Part I				
Basic Design	18	15	11 $\pm$ 1	halfsine shock pulse
-Part II				
Crash Safety	12	30	11 $\pm$ 1	same
MIL-STD-810, Method 516.2				
-Procedure I				
Basic Design				
Flight Veh	18	20	11	same
Ground Equip	18	40	11	same
-Procedure III				
Crash Safety				
Flight Veh.	12	40	11	
Ground Equip.	12	75	6	

The close similarity of the test procedures and test limits indicates that the shock test requirements for both avionics and ground equipments can be met by the worst case test for ground equipment, namely, MIL-STD-810, Method 516.2 which includes the following procedures:

Procedure I, Basic Design, Figure 516.2-1 or 2.
40g, 11 ms for ground equipment, saw tooth pulse.

Procedure III, Crash Safety, Figure 516.2-1 or 2.
75g, 11 ms for ground equipment, saw tooth pulse.

Altitude: Although many avionic equipment specifications require operation at 15.2 km (50,000 feet), it was determined that in practice, Army avionic equipments actually operate only up to 9.14 km (30,000 feet). The worst case altitude environment required can then be specified at 9.14 km (operating) for avionic equipment as compared to 3.14 km (operating) for ground equipment. For low performance Army aircraft, as well as for ground

equipment, cooling differences between 9.14 km and 3.04 km are not significant. Therefore, operation at 9.14 km can be imposed on all Army equipment without additional design burdens on their module assemblies.

Other Environments: All of the other equipment ambient environments listed in Table 2, namely, temperature (non-operating), altitude (non-operating), humidity, salt, fog and fungus do not provide any special management or module design problems for each equipment platform being studied.

b. Module Environmental Requirements: Table 5 lists the equipment-to-module translation factors used for each environment. These factors were described in a recent study conducted by the tri-service subpanel. After application of these translation factors to the equipment composite environment in Table 2, the resulting module environment requirements were recommended for Army usage (See Table 6.). A thermal shock test procedure, selected from MIL-M-28787 (a Navy SEM specification), was added to assure thermal ruggedization of the module assembly. Also, service/life requirements including: transient operating temperature, life durability, flammability, toxicity and hydrogen atmosphere tests were selected from MIL-M-28787 and were included as applicable to Army module requirements.

c. Module Sizes: Data collected for module size configurations (included in Tables 7, 8, 9 and 10) were graphically plotted in the following figures:

	DATA TABLE	MODULE USAGE PLOTS
Manpack	7	Figure 1
Avionics	8	Figure 2
Ground Support	9	Figure 3
Mobile Vehicle	10	Figure 4

Electronic real estate (area available for circuit printing, parts mounting, cooling and connectors) is one of the most significant figures used in calculating module capability. The number of each module size used per equipment was multiplied by the number of equipments estimated to be in existence to obtain the total module population for that size module (shown in the last column of each data table). The population of these sizes was plotted in Figures 1, 2, 3 and 4 tc show the percentage peaks of the size used in each equipment platform category. The percentage curve, including all platform types, is shown in Figure 5.

TABLE 5. EQUIPMENT-MODULE TRANSLATION FACTORS

(Conversion of equipment level environments to module level)

Environment		Factor	Rationale
Temperature		+15°C	Average equip case-module temperature change
Humidity		1:1	Non-Hermetic Case
Altitude		1:1	Non-Hermetic Case
Salt Fog		1:1	Non-Hermetic Case
Fungus		1:1	Non-Hermetic Case
Fungus		1:1	Non-Hermetic Case
Shock		1:1	Amplification of resonances occur as a function of mechanical construction, material thickness and module mounting methods. Factors shown represent worst case based on available field data.
Vibration	Sheltered	3:1	
		5:1 up to 200 Hz	
	Avionics	5:1 up to 200 Hz	
	Manpack	5:1	
	Missile	5:1 10:1 to 3000 Hz	

TABLE 6. RECOMMENDED ENVIRONMENTAL REQUIREMENTS FOR ARMY MODULES

ENVIRONMENT	LIMITS	TEST PROCEDURES
Temperature:		
Operation	-55°C to +85°C	MIL-M-28787, Par 4.5.3.2.2, 4.5.3.2.1
Storage	-62°C to +85°C	MIL-STD-810, Method 500
Relative Humidity:	95% RH at 65°C + condensation	MIL-STD-810, Method 507 Procedure II
Vibration:	5 to 2000 Hz to 5 1.6 g at 0.91 mm	MIL-STD-810, Category C Procedure I
Shock:	Proc I, Basic Design 40 g, 11 ms	MIL-STD-810, Method 516.2
	Proc III Crash Safety 75 g, 11 ms	
Thermal Shock:	-65°C to 125°C	MIL-STD-202, Method 202, Method 107C
Altitude:		
Operating	9.14 km	MIL-STD-810, Method 500
Non-Operating	15.2 km	
Salt Spray:	5% Salt Spray, 100% RH, 48 hours	MIL-STD-810, Method 509
Fungus:	28 Days, 30°C, 95% RH, 5 spores	MIL-STD-810, Method 508

Recommended Service/Life Requirements

Transient Operating Temp	120°C for 2 hours	MIL-M-28787, par 3.3.1, 4.5.3
Life	100°C for 500 hours	MIL-M-28787, par 3.6.1, 4.5.12
Durability	500 cycles	MIL-M-28787, par 3.4.8, 4.5.10.5
Flammability	MIL-STD-454 Requirement 3	MIL-M-28787, par 3.2.3.2, 4.5.19
Toxicity	Bumed. Inst. 6270.2	MIL-M-28787, par 3.2.3.1
Hydrogen Atmosphere	6 hrs @100°C w/10% hydrogen, 90% nitrogen	MIL-M-28787, par 3.3.2, 4.5.2.0

TABLE 7. MANPACK EQUIPMENT MODULE SIZE CONFIGURATIONS

EQUIP	WIDTH cm	WIDTH (in)	HEIGHT cm	HEIGHT (in)	AREA cm^2	AREA (in^2)	MODULE POPULATION PER EQUIP	MODULE POPULATION EST # EQUIP	TOTAL MODULES (thousands)
PRC-70	8.25	(3.25)	5.84	(2.3)	48.4	(7.5)	4	1000	4
	8.25	(3.25)	7.1	(2.8)	58.7	(9.1)	10	1000	10
	8.25	(3.25)	8.4	(3.3)	69.0	(10.7)	3	1000	3
	8.25	(3.25)	9.6	(3.8)	80	(12.4)	6	1000	6
	5.53	(2.18)	5.53	(2.18)	40	(4.8)	2	1000	2
PRC-77	8.4	(3.3)	5.6	(2.2)	21.3	(3.3)	15	150,000	2250
	13.4	(5.3)	4.4	(1.75)	34.2	(5.3)	4	150,000	600
	17.2	(6.8)	5.7	(2.25)	43.9	(6.8)	2	150,000	300
	18.7	(7.4)	4.1	(1.6)	47.7	(7.4)	4	150,000	600
VRC-78 (3D)	6.3	(2.5)	3.2	(1.25)	20.0	(3.1)	*		
(2D)	11.7	(4.6)	6.6	(2.6)	77.4	(12.0)	*		

*NOT SIGNIFICANT

TABLE 8. AVIONIC EQUIPMENT MODULE SIZE CONFIGURATIONS

EQUIP	WIDTH		HEIGHT		AREA		PER EQUIP	EST # EQUIP	TOTAL MODULES (thousands)
	cm	(in)	cm	(in)	cm^2	(in^2)			
ARC-115	12.0	(4.75)	6.1	(2.4)	73.5	(11.4)	3	8	24
	6.3	(2.5)	3.8	(1.5)	24.2	(3.75)	8	8	64
ARC-164	11.4	(4.5)	10.2	(4.0)	116.1	(18.0)	6	10	60
ARC-89	15.2	(6.0)	12.0	(4.75)	183.8	(28.5)	3	4	12
	7.6	(3.0)	11.4	(4.5)	87.0	(13.5)	2	4	8
	3.8	(.15)	5.1	(2.0)	19.3	(3.0)	2	4	8

TABLE 9. Ground Support (Test Equipment) Size Configuration

EQUIP	WIDTH cm	WIDTH (in)	HEIGHT cm	HEIGHT (in)	AREA cm^2	AREA (in^2)	MODULE POPULATION PER EQUIPMENT	MODULE POPULATION EST # EQUIPMENT	MODULE POPULATION TOTAL MODULES (thousands)
USM-40	26.7	(4.15)	19.3	(3.0)	80.0	(12.4)	38	100	3.8
	44.5	(6.9)	26.4	(4.1)	183.8	(28.5)	8	100	0.8
	58.0	(9.0)	19.3	(3.0)	168.3	(26.1)	5	100	0.5
	70.9	(11.0)	45.1	(7.0)	496.0	(76.9)	6	100	0.6
TPM-25	30.9	(4.8)	36.1	(5.6)	172.2	(26.7)	11	5000	55
APM-305	30.9	(4.8)	36.1	(5.6)	172.2	(26.7)	11	5000	55
APM-123	28.4	(4.4)	32.2	(5.0)	141.9	(22.0)	14	5000	70

TABLE 10. MOBILE-VEHICLE EQUIPMENT MODULE SIZE CONFIGURATIONS

EQUIP	WIDTH cm	(in)	HEIGHT cm	(in)	AREA cm^2	(in^2)	MODULE POPULATION PER EQUIPMENT	EST # OF EQUIPMENT	TOTAL MODULES (thousands)
GSG-10 (TACFIRE)	13.7	(5.4)	3.3	(1.3)	45.1	(7)	1900	10	19
	13.7	(5.4)	10.4	(4.1)	142.5	(22.1)	100		1
TTC-38	8.4	(3.3)	22.1	(8.7)	186.4	(28.9)	2819	34	95.8
	11.4	(4.5)	7.1	(2.8)	81.3	(12.6)	865		29.4
TTC-39	15.2	(6)	25.4	(10)	387	(6)	2000	50	100
	13.7	(5.4)	3.3	(1.3)	45.1	(7)	3000		150
TPQ-36	17.8	(7)	20.3	(8)	361	(56)	143	100	14.3
TSQ-73	13.7	(5.4)	3.3	(1.3)	45.9	(7.13)	3769	10	37.69
SAM-D	15.7	(6.2)	8.1	(3.2)	129	(20)	1000*	10	10
	16.5	(6.5)	7.8	(3.1)	129	(20)	1000*		10
	3.0	(.12)	6.1	(2.4)	18.1	(2.8)	500*		5
	2.9	(1.16)	2.0	(1.16)	8.4	(1.3)	250*		2.5

*APPROXIMATE

TABLE 11. PEAK AREAS

PERCENTAGE OF TOTAL	PEAK AREA (in^2)	cm^2	EQUIPMENT MODULE
50	(3.3)	21.3	Manpack, Avionics
14	(3.75)	24.2	Manpack
13.6	(7.4)	47.7	Manpack, Mobile Vehicle
2.0	(18)	116	Avionics
1.6	(22)	142	Test Equipment
2.4	(26.74)	172.5	Test Equipment
2.4	(28.9)	186.4	Test Equipment
2.2	(60)	387	Mobile Vehicle
88.2*			

*11.8% constitutes less significant peaks not identified

Table 11 tabulation indicates that current Army equipment categories do have module usage peaks in printed wiring board areas that need to be considered in an Army standardization program.

d. Development of Proposed Army Strawman Standard Module Sizes:

In planning for the development of proposed standard module sizes, the applicability and use of existing standard module sizes such as Navy SEM, Quick and Easy Design (QED) Air Transport Regulations (ATR) need to be included. These are briefly described in the following paragraphs.

Navy SEM: The Navy Standard Electronic Module[4] is the only established military on-going program. It was initiated in 1965 and has over 12 years of application and field experience. Figure 6 indicates the applicable specifications currently being coordinated for possible tri-service usage. The Naval Avionic Facility (NAFI), Indianapolis, IN, and Naval Weapons Support Center, Crane, IN, provide module design reviews and qualification testing and approval of modules, 267 of which have been identified and 180 documented and approved to date. The basic module

4 "A Functional Approach to Navy Electronic Standardization", Document No. NAVELEX 054A, The Navy Standard Hardware Program, Nov 1973.

configuration is shown in Figure 7, growth capability is shown in Figure 8. Currently, two basic sizes are used (see Table 12). An improved Super 2 with a 100 pin connection is currently being developed with the same envelope size as the SEM 2.

The Navy's 2175 Program, "Quick and Easy Design (QED) Hardware Standardization",[5] was established and used by the Naval Electronics Laboratory Center. The QED-sized card has the same width as the SEM 2A at 14.3 cm (5.62 in), but with a 12.6 cm (4.95 in) height (See Figure 9) and is incremental with the Navy SEM.

Air Force Standard Electronic Modules for Avionics: In 1975 and 1976, the Air Force conducted extensive studies and industry tri-service meetings at the Bergamo Conferences and at the Air Force Avionic Laboratory, Dayton, OH, in order to determine the feasibility of adopting Standard Avionic Modules (SAM).[6] Results of these studies have been published in the following reports:

AFAL-TR-76-126 (Hydrospace Challenger Inc.)[7]

AFAL-TR-76-61 (Westinghouse)[8]

AFAL-TR-122 (Hughes)[9]

As a result of the above studies, the following module dimensions and physical configurations were found to be the most compatible with Air Force avionic equipment.

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5 Urban, E. C., "Quick and Easy Design (QED) Hardware Standardization", 2175 Program, TD 319, NELC, 11 Jun 1974.
6 "AFAL Preliminary Recommendations on Standard Electronic Modules for Avionics", 1 Sep 1976.
7 "AF/Industry Standard Electronic Module Workshops", AFAL-TR-76-126, Hydrospace Challenger, Inc., EGG, Sep 1976.
8 "Modular Packaging Approaches", AFAL-TR-76-61, Westinghouse Elec. Corp., Jun 1976.
9 "Functional and Configuration Analysis Program", Contract F33615-76-1270, Hughes Aircraft Co., May 1975 - Oct 1976 - Final Report.

TABLE 12. ATR* MODULE SIZES

MODULE SIZE	1/2 ATR	3/4 ATR	FULL ATR
Width	11.3 cm (4.46 in)	19.1 cm (7.5 in)	24.6 cm (9.7 in)
Height	16.7 cm (6.57 in)	1.67 cm (6.57 in)	16.7 cm (6.57 in)
Pitch	1.27 cm (0.5 in)	1.27 cm (0.5 in)	1.27 cm (0.5 in)
Usable Width	8.03 cm (3.16 in)	14.7 cm (5.78 in)	21.3 cm (8.4 in)
Usable Height	13.3 cm (5.25 in)	13.3 cm (5.25 in)	13.3 cm (5.25 in)
No. pins/0.25 cm (0.1 in)	100	204	296
No. of test pins	50	102	154
Type of connector	NAFI	NAFI	NAFI
Est Max Power	35 W	30 W	25 W

The Air Force, however, has postponed adoption of any standard until further support data is available to justify usage.

*Air Transport Regulation Modules (ATR): Table 12 listed ATR box sizes and module dimensions are part of the standardized Air Transport Regulation developed by Aeronautical Radio Inc.[10] and are currently in common usage by commercial and some military aircraft avionics. Adoption of these sizes would provide immediate hardware availability and cost-effective savings. Although control panel applications, such as those used in Army avionic (low performance aircraft) applications, are not compatible with the ATR configurations, they can use the size modules which are listed in Table 13. ATR sizes, such as those being considered for SAM usage, can be used by computer and ground-based Army applications as a ready-available standardized module size with all of its inherent advantages. The full ATR module size is being considered for use in the Military Computer Family (MCF) in Army-Navy Tactical Computer Standardization Programs.[11]

10 ARINC Specification No. 404.

11 Preliminary Report, "Military Computer Family Systems Configuration Handbook", Contract DAAB07-76-C-0392. ITEK, 15 June 1977.

TABLE 13. PROPOSED ARMY "STRAWMAN" MODULE SIZES

No.	*ATR Navy SEM	Width cm	Width in	Height cm	Height in	Area cm^2	Current Army Peak Usage cm^2	Equipment Category
1		2.84	1.12	2.84	1.12	8.06		
2		6.65	2.62	3.43	1.35	22.8	21-24	Manpack, Avionics
3	SEM 1A	6.65	2.62	4.95	1.95	32.9		
4		9.5	3.74	4.95	1.95	47.0	47.7	Manpack, Mobile-Veh.
5	SEM 2A	14.3	5.62	4.95	1.95	70.8		
6		14.3	5.62	12.6	3.90	141.7	116-142	Test Equipment
7	QED	14.3	5.62	12.6	4.95	180	172-186	Test Equipment
8	*1/2 ATR	11.33	4.46	16.69	6.57	189		Computers
9		21.9	8.62	12.6	4.95	276		
10	*3/4 ATR	17.98	7.08	16.69	6.57	300		
11		29.5	11.62	12.6	4.95	371.7	387	Mobile Vehicle Computers
12	*Full ATR	24.6	9.7	6.69	6.57	410.6		MCF

*Air Transport Regulation

PROPOSED ARMY "STRAWMAN" MODULES

The proposed Army "strawman" module sizes are shown in Figure 10. Numbers 2, 4, 6, 7 and 11 have been calculated to satisfy the area size requirement of each Army equipment platform category studied for this report. Wherever possible, width increments were selected to follow the Navy SEM requirement that width increments be limited to 7.62 cms (3 in).

The smallest sized module is 8.06 cm^2 and is included as a possible circuit module for future accommodation to smaller manpack equipment designs. The 2.84 cm (1.12 in) width for this module is half the Navy 1A module width of 6.65 cm (2.62 in). Module No. 1 was proposed with a 2.84 cm (1.12 in) width because two of them could be racked with a Navy 1A module with a 0.96 cm (0.38 in) space. (The available space between two 1A widths when racked with the Navy 2A.) This space would allow for racking hardware in between modules racked edge-to-edge. (See Figure 11.)

Module No. 4 was included to satisfy manpack and mobile-vehicle platform designs.

Modules 3 and 5 are the Navy SEM sizes. Module No. 7, (Navy QED), was added because they are currently being used by some future families of computer systems and are near peak usage size used by test equipment platforms.

Three ATR module sizes are included. These represent a large group of established commercial aircraft standardized modules and are being considered for the military computer family program.

The proposed module sizes shown in Table 12 are only "strawman" sizes and are intended to show the range of module sizes required by the Army in current and near future platform and system applications. Table 13 also includes various already-established, available and large-usage standard module sizes. Exact and detailed form-fit configurations for the six Army modules would have to be developed and designed before the final standard form-fit modules could be proposed in specification form. A study must be conducted to also develop, design and fit the proposed sizes into a coordinated set of card files, interconnection and mother-board matrices which will optimize overall compatibility.

a. Form-Fit Design Criteria: In addition to environmental and size designs, the following are additional form-fit requirements which have to be considered in the design of Army modules.

Connectors: Since module connectors affect module reliability and the ability of the various sized modules to fit and interconnect, the selection of the connectors needs to be especially considered. Two connector types are proposed for Army SEM usage. They are:

NAFI module connectors are recommended for current usage. These connectors are tuning fork-bayonet type connectors, per MIL-C-28754, and para 5.11.5 of MIL-STD-1389. Module keying could be in accordance with para 5.1.1.6 of MIL-STD-1389. This connector is a qualified, rugged and highly reliable design with more than ten years of Navy SEM field usage.

Since many advanced Army module designs are requiring high pin counts per module, consideration must be given in future study programs to connectors with higher pin densities and lower insertion-withdrawal forces. They must also be consistent with lower life-cycle cost objectives by being procurable at much lower cost levels than is currently possible under MIL-P-55302.

Module Test Points: The need for exposed test points available in an applied test equipment probe to facilitate fault indication and location should be determined.

Thermal Management: For Army application, thermal management should be limited to conduction, convection and low power air-cooling methods. Thermal management should be sufficient to meet the Class 2 system ambient in accordance with MIL-E-5400 and the module environment requirements listed in Table 6 of this report. In general, solid state region junction maximum temperature should be at 125°C. Power dissipation of up to 2 watts per in^2 should be accomplished by convection or conduction cooling. A Δ T should be specified from a designated reference module point to the solid state junction temperature.

b. <u>Army Trade-Off Design Criteria</u>: For each of the four platform types included in this study, any design of the proposed "strawman" modules should include the consideration of trade-off design criteria which prioritizes the special needs of that platform type. The design criteria are defined as follows:

Technology Compatibility - The capability of the module to accommodate different types of devices and device technologies efficiently; dual in-line packages, flatpacks, large-scale integration, hybrids, leadless carriers or any other technology that may be developed.

Function Flexibility - The ability of the module to accept the circuit designs necessary to perform the electronic functions required by system and equipment specifications.

Reliability - The ability of the module to perform its specified function for the required length of time without electrical or mechanical failure under the environmental conditions which are to be encountered in the field.

Function Density (wt. and vol.) - The amount of hardware required, measured by weight and volume of the module, to perform the specified electronic functions.

Cost - The overall life cycle cost of the module. This includes development, qualification, production costs and field usage.

Power Demand - The watts required per module function.

Application Flexibility - The ability of the module design to meet the physical and electrical requirements of a broad range of equipments, platforms, systems and supporting structures.

System Maintainability - Design characteristics of the module system such as fault location, ease of component replacement, testability and repairability that will expedite system maintenance and reduce equipment downtime.

For each of the platform types, each of these design criteria have been prioritized and are listed in Table 14. The design of each module should take into consideration the trade-offs necessary to achieve such criteria as listed.

TABLE 14. ASEM DESIGN CRITERIA PRIORITY

EQUIPMENT PLATFORMS

MANPACK	AVIONICS	TEST	MOBILE VEHICLE
Power Demand	Functional Flex.	Tech. Comp.	Tech. Comp
Wt. & Vol.	Wt. & Vol.	Func. Flex.	Reliability
Reliability	Reliability	Reliability	Functional Flex.
Cost	Tech. Comp.	Applic. Flex.	System Maint.
Applic. Flex.	Cost	System Maint.	Applic. Flex.
Func. Flex.	Power Demand	Wt. & Vol.	Wt. & Vol.
System Maint.	Applic. Flex.	Power Demand	Power Demand

CONCLUSIONS:

A study of the Army equipment, selected on a sampling basis, indicates that proliferation of modules can be reduced by the initial use of proposed mechanical-environmental standards because of peak usage of certain discrete module sizes and common environmental requirements.

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9. AFAL-TR-76-122, "Functional and Configuration Analysis Program", Contract F33615-76-C-1270, Hughes Aircraft Co., May 1975 - Oct 1976, Final Report.

10. ARINC Specification No. 404.

11. Preliminary Report, "Military Computer Family Systems Configuration Handbook", Contract DAAB07-76-C-0392, ITEK, 15 June 1977.

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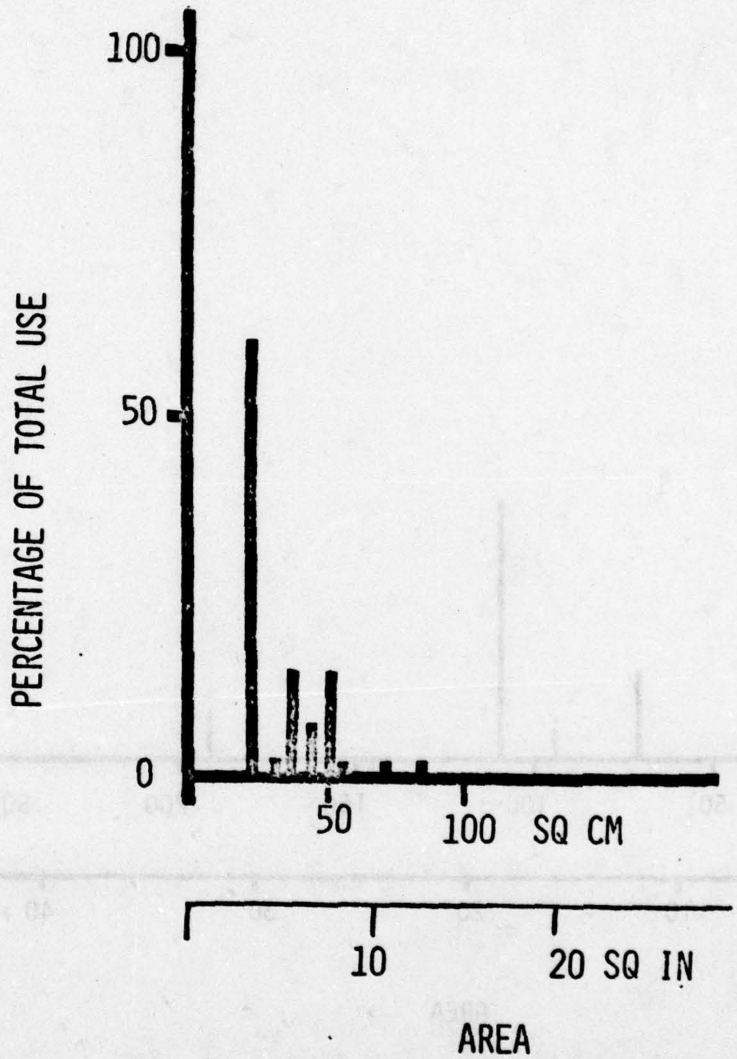


Figure 1.
MODULE USE DISTRIBUTION: MANPACK

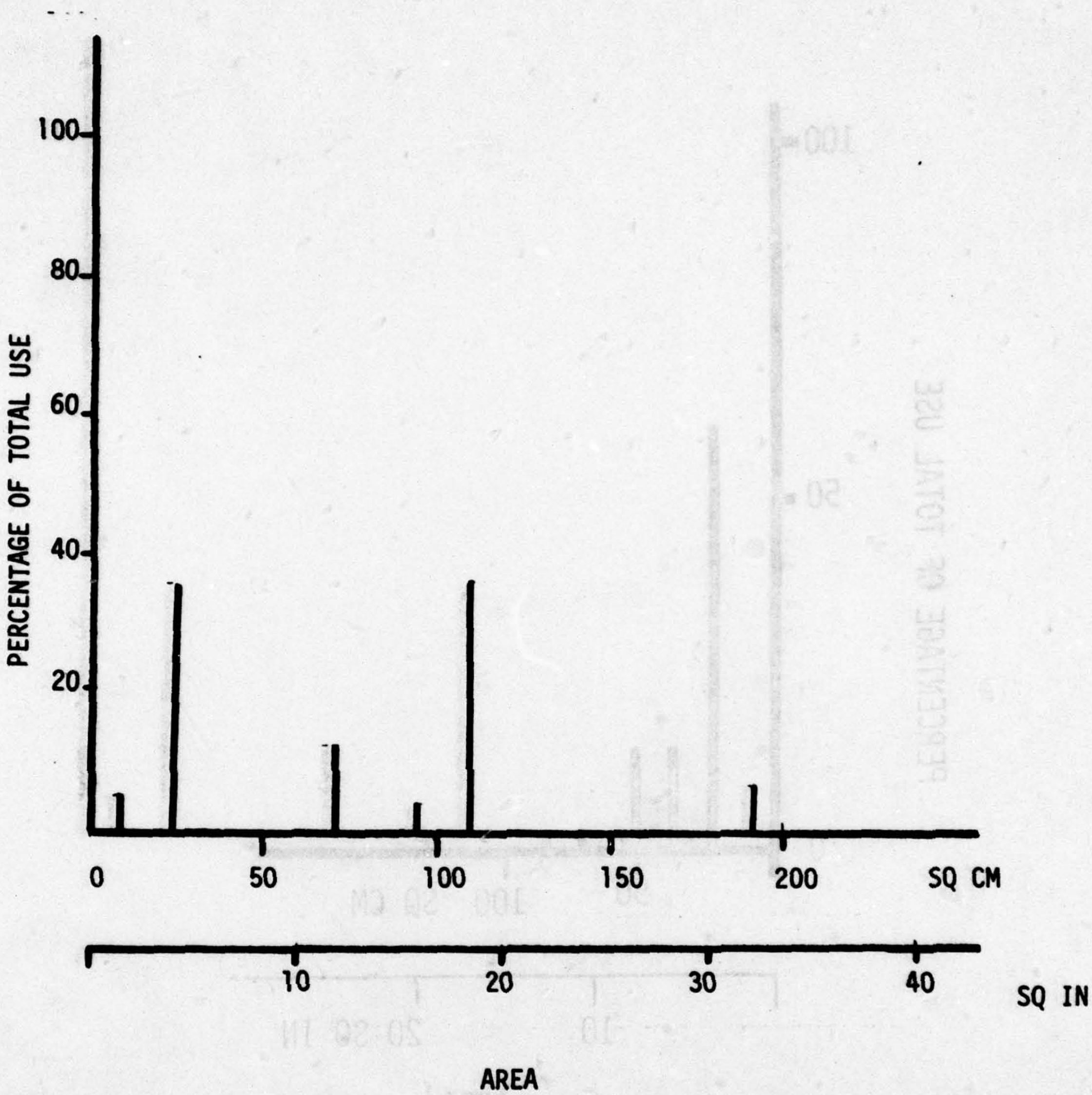


Figure 2.
MODULE USE DISTRIBUTION: AVIONICS

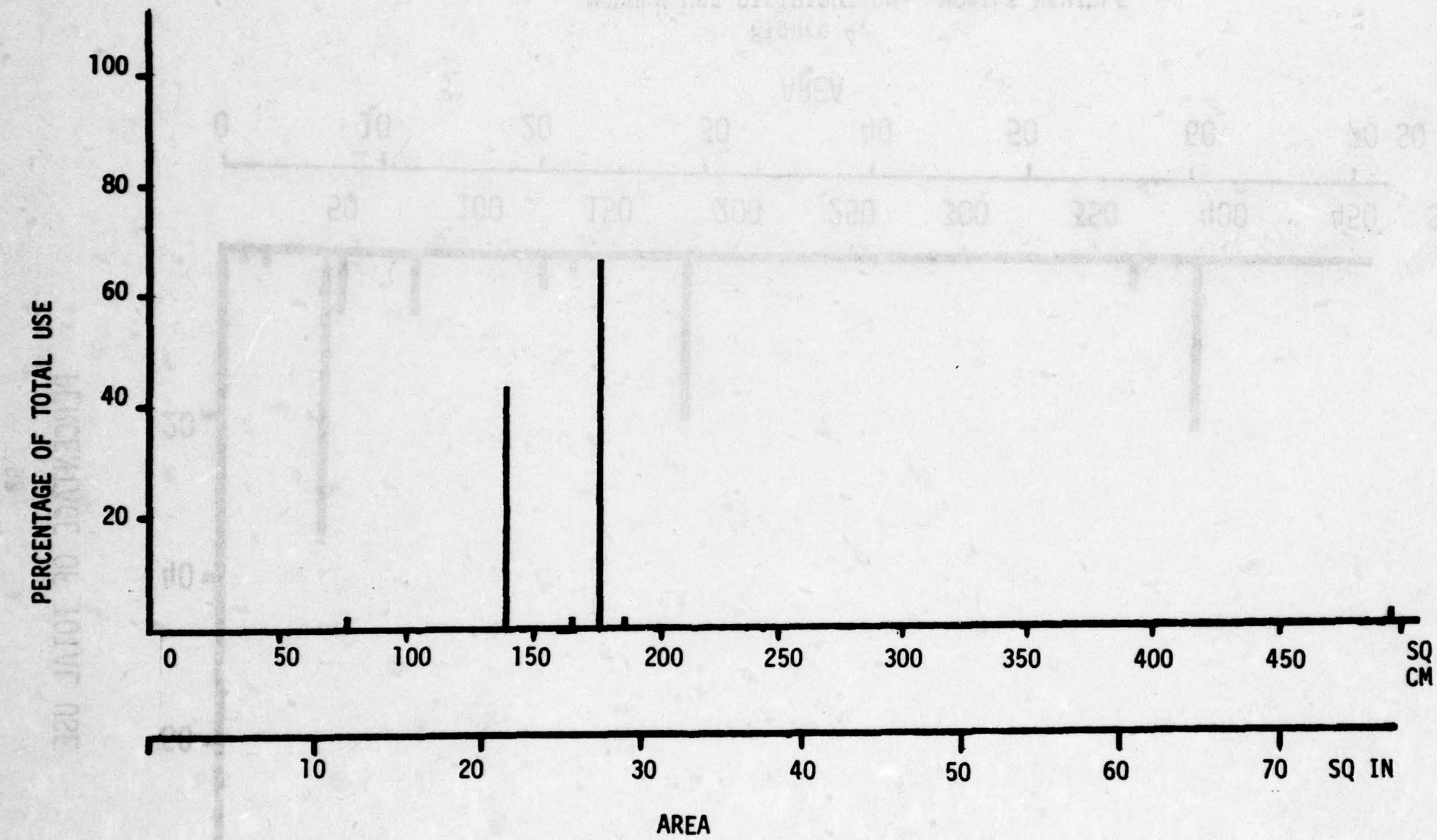


Figure 3.
MODULE USE DISTRIBUTION: Ground Support (Test Equipment)

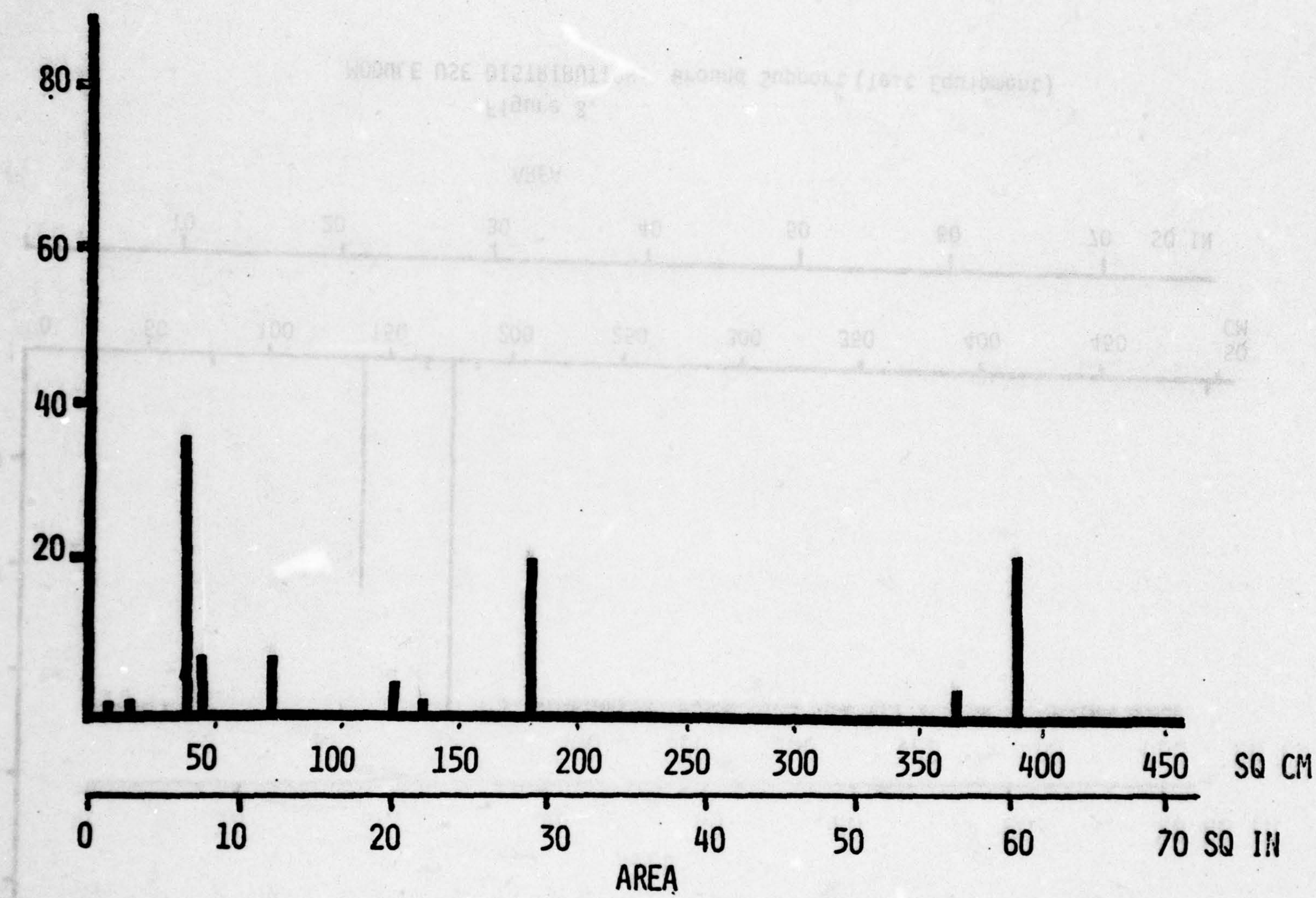


Figure 4.
MODULE USE DISTRIBUTION: MOBILE VEHICLE

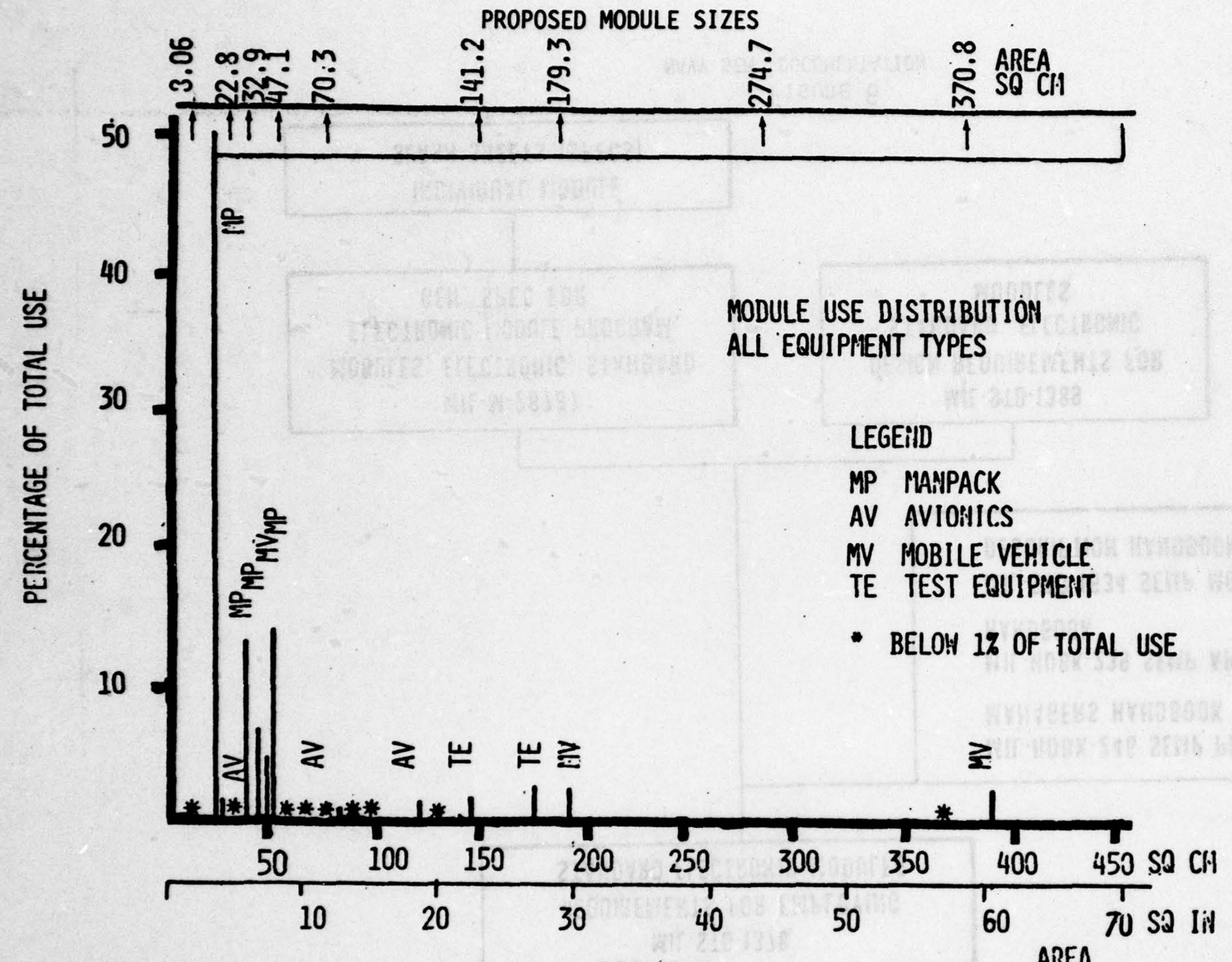


FIGURE 5

MODULE USE DISTRIBUTION ALL EQUIPMENT TYPES

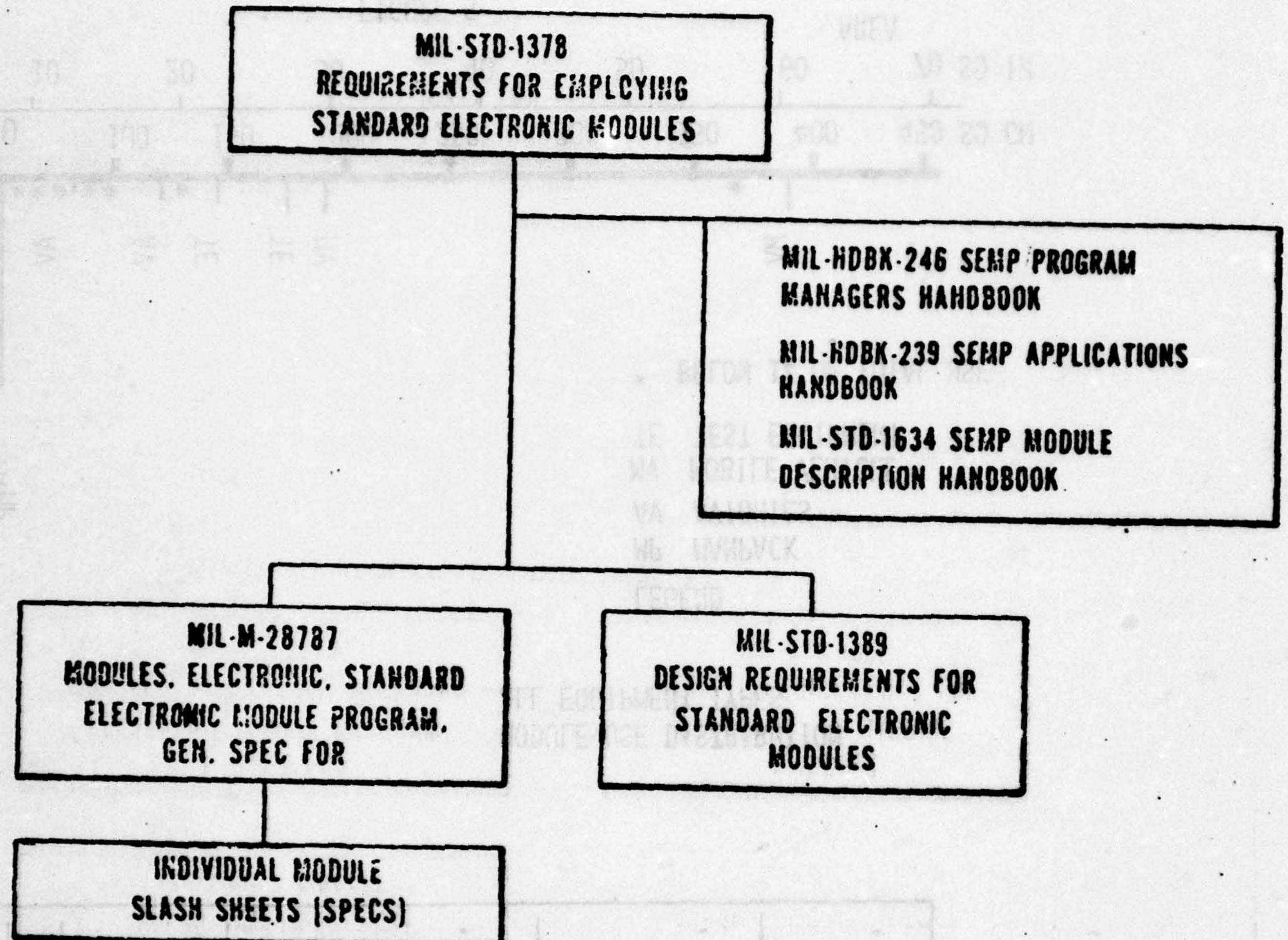


FIGURE 6
NAVY SEM DOCUMENTATION

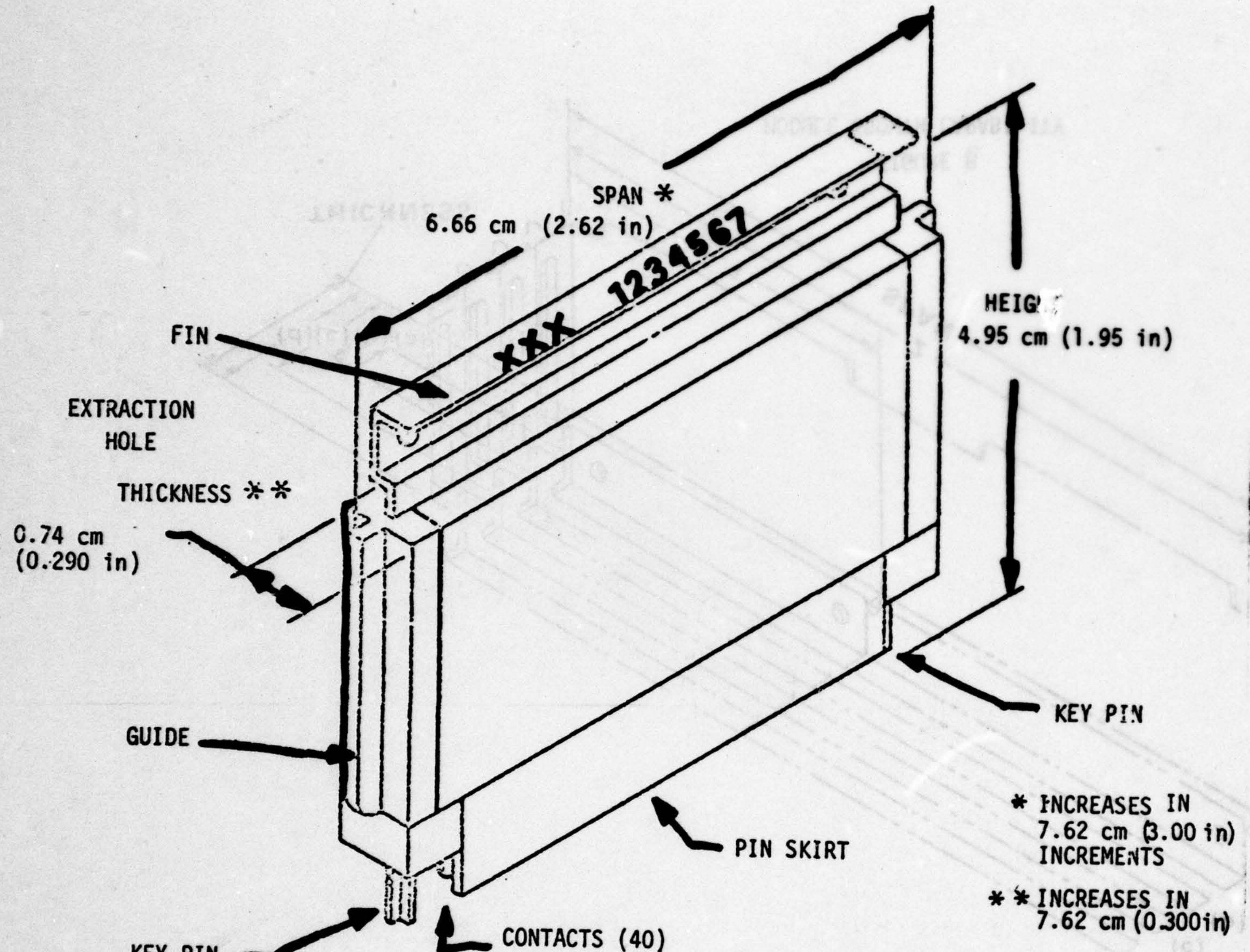


FIGURE 7
MODULE CONFIGURATION

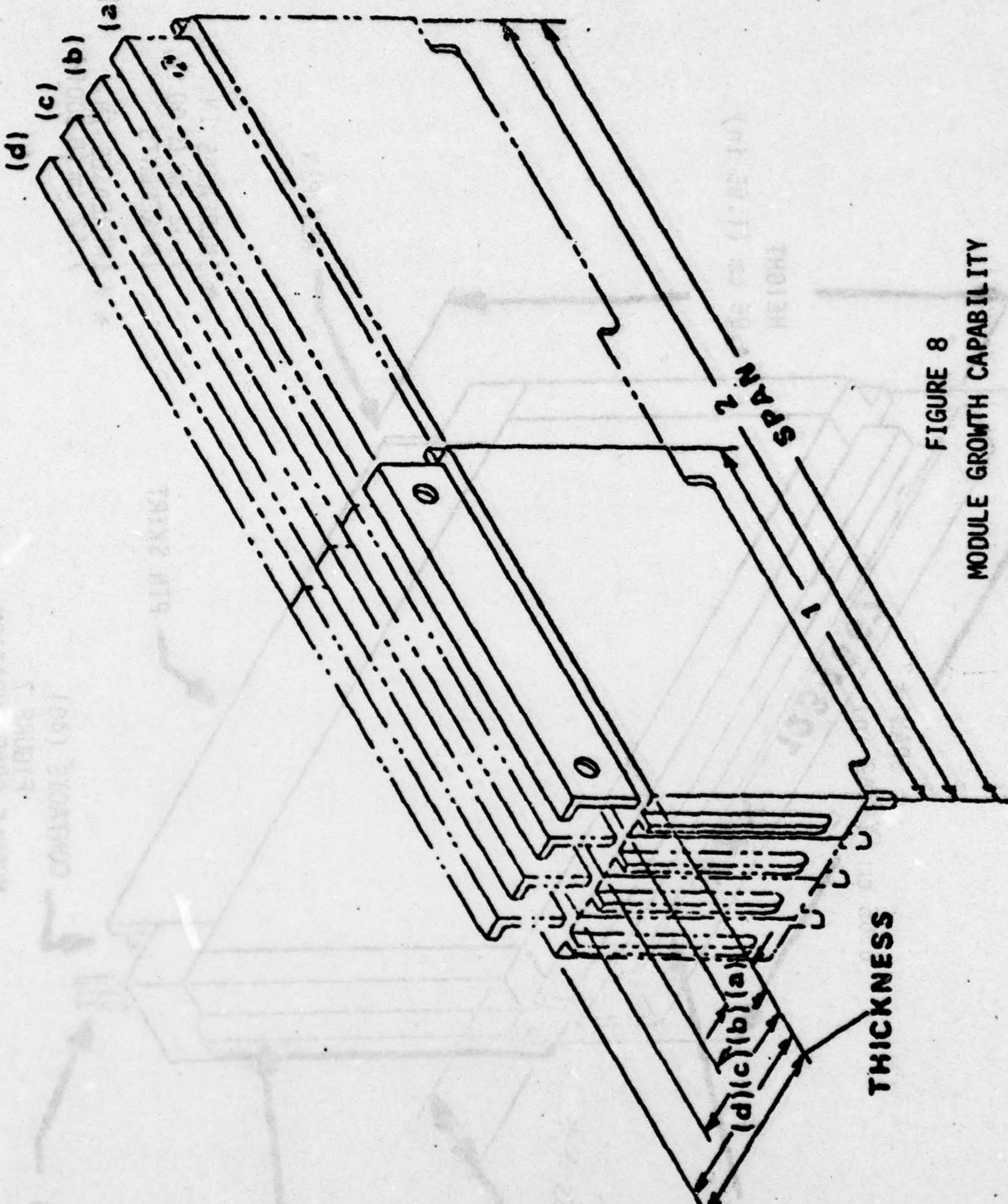
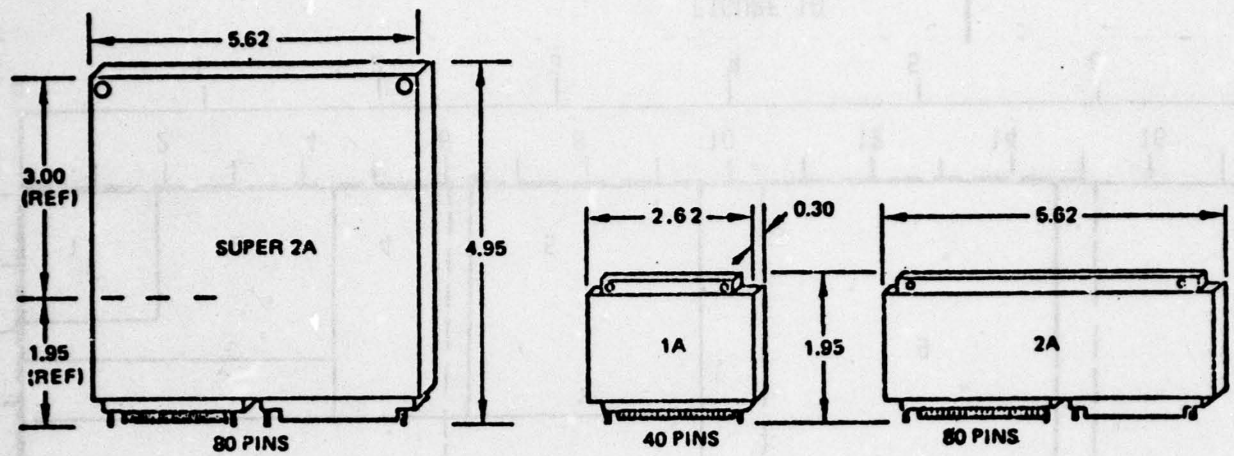


FIGURE 8
MODULE GROWTH CAPABILITY



SUPER 2A:

- USES "SHP" PHYSICAL CONFIGURATION "+ 3"
- USED FOR BREADBOARD AND PROTOTYPE – MORE AREA THAN EXISTING 2A STD

FIGURE 9

SIZE RELATIONSHIP OF QED CARD TO SHP MODULES

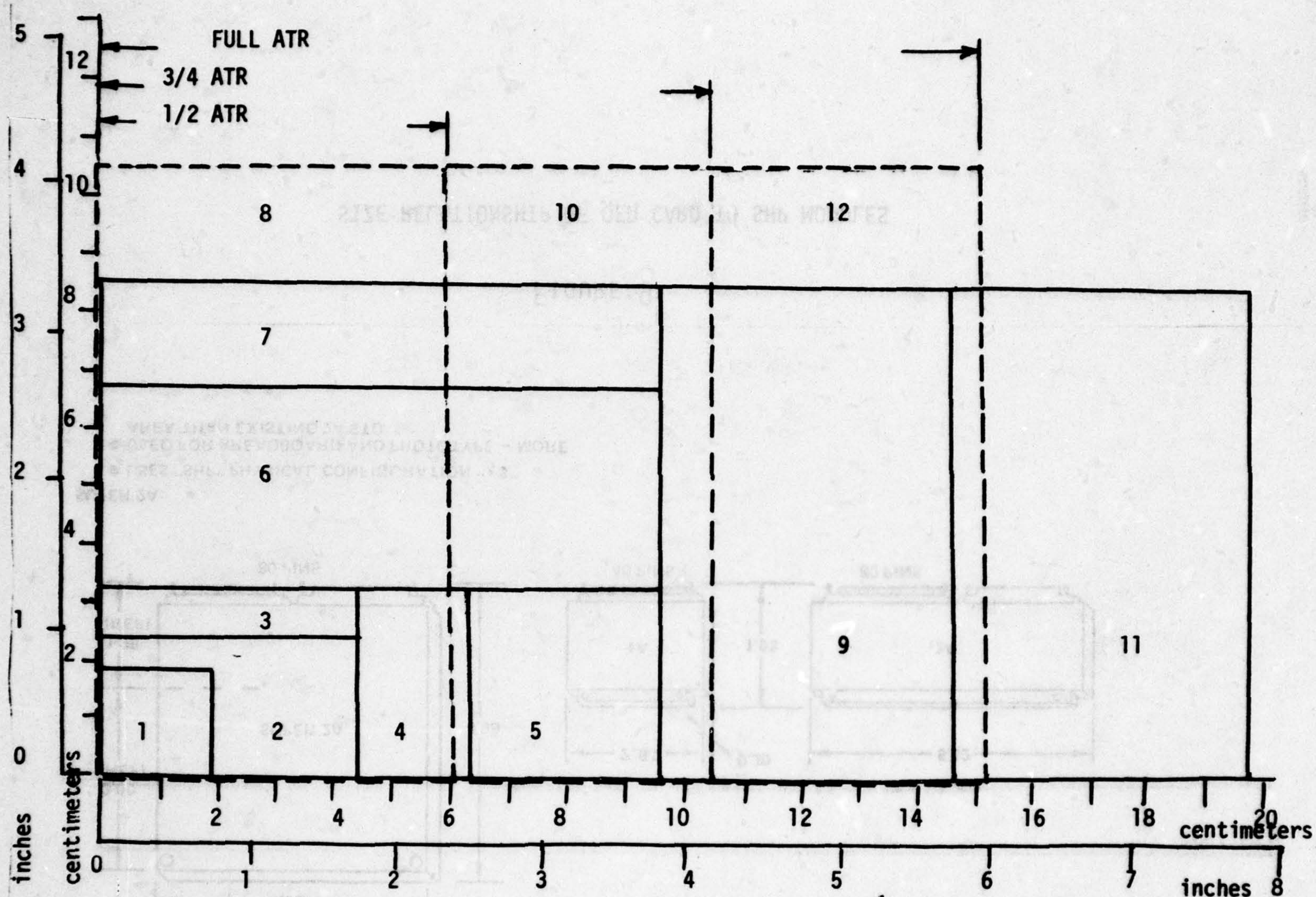


FIGURE 10
ASEM OVERLAY CHART

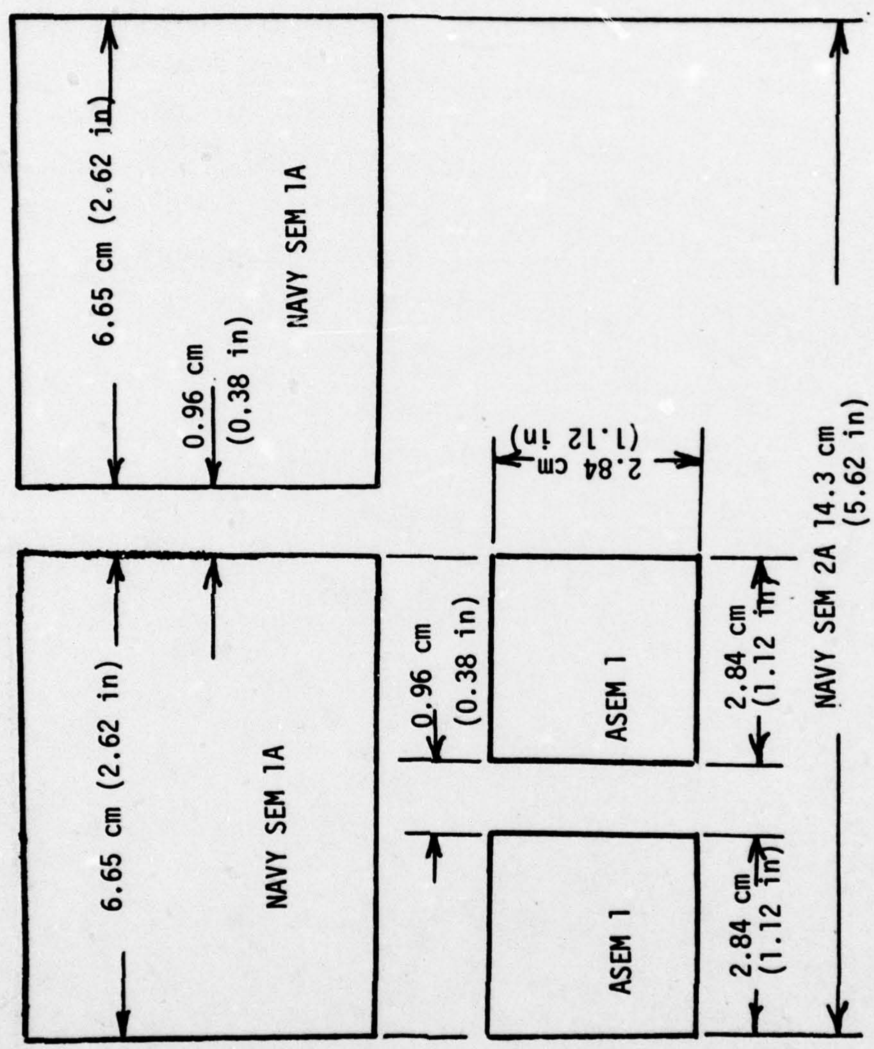


FIGURE 11
MODULE INCREMENTS